

## Cleaner Fuel Vehicles - Saving You Money in America

Imagine driving the car of your dreams. Now realize the engine in this vehicle cleaning the air as you drive. Visualize the fuel for your automobile costing less than what you pay today for gasoline. Picture your motor lasting longer than any you have ever had before. Now think about filling your tank with a fuel that does not require hostility, greed or fear.

This is not a dream. Right now this is reality and this author is enjoying all the benefits of cleaner fuels. I am going to share some of my knowledge to help you choose the best fuel for you today and tomorrow.

I want you to be able to use a locally produced fuel that decreases your transportation cost and reduces airborne emissions. Why pay more for dirtier, life threatening oil from foreign sources?

I know of 7 “alternative” fuels that people use today that can all be obtained at less cost than gasoline or diesel. All of these options contribute to the good health of our economy, and of Earth’s inhabitants.

Propane has been used successfully in gasoline engines as a motor fuel for decades. Its price used to be much cheaper before current taxes. Most all of the country can enjoy this slightly cleaner than gasoline fuel at a lower cost than premium unleaded. As of October, 2004, Dallas had the highest propane prices at \$1.93 per gallon of gasoline equivalent (g.g.e.) Billings, MT reported the lowest price at \$1.22 per g.g.e.

Propane can also be used to boost performance of compression ignition engines. Pilot point ignition of propane on top of diesel or biodiesel increases combustion. This will provide more horsepower while reducing exhaust gas emissions. This is great for saving time and money while towing heavy loads.

Biodiesel is an amazing replacement for diesel fuel, because it can be used directly without any modifications. Biodiesel can be produced from any fatty ester such as fresh plant oils, animal fat or used cooking oils. When mixing these oils with the proper amounts of methanol, or ethanol and lye, an individual can produce their own fuel for as little as \$0.70 cents per gallon. Biodiesel can be purchased at commercial fuel stations and regional co-ops around the country right now. Dallas has the lowest price B-20 (20% bio, 80% petro) for \$1.72 per gallon and Honolulu sells B-100 for \$2.15. For anyone driving a vehicle that requires diesel, biodiesel is clearly the alternative. Among the many advantages of this non-toxic fuel is the fact that American farmers produce it. In some engines, especially the older, dirtier, more worn in ones, biodiesel reduces friction. This can provide increased horsepower and miles per gallon while reducing visible smoke and nasty smell.

Another option for compression ignition engines is straight veggie oil, (SVO) from raw, virgin oil. Or waste veggie oil, (WVO) from the grease traps of the nation. This stuff straight, or filtered is not the same as biodiesel, but is what Rudolph Diesel designed his engine to run on which debuted at the Worlds Fair in Paris, 1900. Talk about cheap fuel, some restaurants will pay you to haul away their waste oil, so you can actually get paid to fill your tank!

Going back further to Germany in the mid 1800’s, a man named Nicolaus Otto developed a cycle to run what we now know as the 4-stroke internal combustion engine (ICE). Although there were a variety of fuels available to run this new engine on, Otto chose producer gas. Producer gas, also called Towns gas or lamp fuel is basically carbonated hydrogen. Otto chose this fuel not because of its wide availability, but because it was safer than the new alternative. Benzene was then the new alternative and is now what we know as a deadly component of gasoline.

Today we have 2 different kinds of hydrogen available for use as a motor fuel. Both renewable and non-renewable forms of hydrogen come with many different names to describe them. The least

## INTERGALACTIC HYDROGEN : American Fuel Vehicles

desirable H<sub>2</sub> is what I call “caged” hydrogen. This could be considered “dirty” hydrogen made from non renewable sources. This “black” hydrogen is available from a low of \$4.50 per kilo derived from grid powered electrolysis, to a high of over \$100 per kilo from the steam reformation of methane. A kilo of hydrogen has almost exactly as many BTU’s as a gallon of gasoline. However, when hydrogen is burned in an internal combustion engine (H<sub>2</sub>ICE), you can expect roughly twice as many miles per kilo as you would get miles per gallon. This makes the cost of dirty hydrogen anywhere from 2x times, up to 50x times the cost of gasoline.

The good news is we have a clean, green and renewable source of hydrogen at much lower cost. When hydrogen is produced through electrolysis of water using renewable, or solar, electricity, we get what I call “free-range” hydrogen. At Arizona Public Service, in downtown Phoenix, they offer “green” hydrogen for \$2.25 per kilo. This breakthrough allows motorists to operate their vehicle for 1/2 the cost of gasoline! Solar derived hydrogen is the cleanest fuel available. Hydrogen not only keeps your engine oil clean, but burning it can produce cleaner air out the tailpipe than the air we breathe in any metropolitan city.

Methane is another fuel that has 2 distinct varieties. Most of the natural gas used for vehicles today, whether liquefied at cold temperatures, or compressed to high pressure comes from oil wells and coal mines. Although this supply is finite, natural gas in Utah is .91 cents per g.g.e. today. At that price, CNG is less than half the cost of gasoline!

Natural gas does have greatly reduced exhaust emissions when burned in an engine. Since this fuel is so clean, the oil in your engine stays clean a lot longer and can increase the life of your engine. This reduces maintenance costs, which in the long run can save fleet operators and individual’s lots of time and money.

There is a very large, untapped source for “renewable” methane in this country. Piling up in feed lots, brewing in land fills and bubbling out of sewage is a usable fuel that would be much better put to use for transportation than allowed to escape into Earth’s atmosphere. We can also make bio gas from grass clippings and other decomposing matter. Collecting these gasses and compressing them for use as a motor fuel is easy and inexpensive. This is the clean fuel of choice in Sweden. With renewable natural gas we can support our local farmers, bolster our economy and increase our nation’s security. Most of the components that refuel and make an engine burn natural gas are the same components needed to run hydrogen through any engine. By embracing natural gas, we get one step closer to a hydrogen powered future.

Another locally produced fuel we can use right now with these same benefits is ethanol. Today there are millions of flex-fuel vehicles on the road that can use either gasoline, or up to 85% ethanol. Although more E85 pumps are being installed at gas stations everyday, we could use a whole lot more to meet the demand of existing vehicles. When ethanol is produced in large quantities in “energy parks”, where multiple industries are using each other’s waste, the fuel is efficient and economical. In Columbus, Ohio, a gallon of E85 sells for \$1.43 and the National Ethanol Vehicle Coalition regularly promotes E85 at stations around the nation for .85 cents a gallon.

Individuals can also produce alcohol from a still at their business, school or residence to save money on fuel and reduce their use of gasoline. You do not need a flex-fuel vehicle to use this American made fuel. Just about any car out there, without modification, can use up to 30% ethanol mixed with gasoline. Ethanol can lower tailpipe emissions, but when used in a non flex-fuel vehicle a fuel economy loss of about 10% will result. Depending on the cost of ethanol available to you this can still add up to a savings to your pocket book.

While natural gas is paving the highway to hydrogen, today’s electric cars are building a bridge to fuel cell vehicles. There are many capable electric vehicles today. With a charger at home and one at work or onboard your EV, you can be charging your vehicle whenever it is parked. Your fuel cost will depend on the price of electricity available to you. The current electricity market lists New York with

## INTERGALACTIC HYDROGEN : American Fuel Vehicles

the highest price per kilo watt hour at \$0.12 cents. West Virginia has the lowest electricity prices at 5.3 cents per kilo watt hour. With the current electric vehicle and quick charger station project in Hawaii you do not even have to wait 8 hours for a full charge of your EV's batteries. While shopping or taking a lunch break on the island of Oahu, the batteries on an EV can obtain an 80% charge in just 20 - 30 minutes! With 11 quick charge stations on the island, EV's are a practical and economical way to travel around this forward thinking community. Electric vehicles also reduce an often overlooked pollution, noise.

The only way to grow demand for these cleaner, safer, healthier and more economical fuels is to let people know about their benefits. Most people do not know these options exist. When in reality they are not new, it is just that we are coming full circle in our fuel choices and returning to the fuels that engines were originally intended to run on. That is why I implore you to join the clean fuel revolution. If you put E85 in your SUV, put a sticker on it too that lets people know you are using less gasoline. If your trade in your car for a CNG vehicle to have the ability to use in the car pool lane with only a single occupant, tell your co-workers about this time and money saving advantage. If you drive a diesel truck, school bus, or big rig, fill it up with biodiesel. Your engine will love it and all the kids breathing the exhaust will thank you. If an EV or neighborhood EV can fit your needs, then use it for errands or short commutes and leave your family hauler parked at home. If you can afford the initial investment to convert your vehicles engine to run on hydrogen, you will be paid back continually through less expensive "solar" hydrogen and through the do good factor. If you simply must use petroleum, get a hybrid and burn less of it.



Tai Robinson with Yukihiro Okane, Highlander Chief Engineer

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*Tai Robinson drives his H2TOY Tacoma to renewable energy events around America demonstrating hydrogen, natural gas, ethanol, biodiesel, propane, methanol, solar and wind electricity to promote the clean fuel revolution. In 2003 his truck made history by leading Dennis Weaver's Drive to Survive from coast to coast using compressed hydrogen for fuel. Tai teaches about the benefits of cleaner fuels to government officials, business owners, fleet operators and students at primary schools and universities. Tai got his start in energy conservation very early on by watching his father design and build engines that run on hydrogen fuel. Later on while Tai was in school he also became a champion athlete competing on the World Cup tour as an Aerialist for the U.S. Freestyle Ski Team. Since then, Tai has joined forces with his father, Fred Robinson to create Intergalactic Hydrogen, a vehicle integration, fuel system upgrade and technology advancement enterprise. Intergalactic offers cleaner fuel vehicles to fleets and retail customers. To learn more about how you can declare energy independence, start your search at: [www.IntergalacticHydrogen.com](http://www.IntergalacticHydrogen.com)*

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### Definitions of abbreviations:

**H<sub>2</sub>** – hydrogen (stored as gas, liquid or solid)  
**H<sub>2</sub>O** – 20% hydrogen w/ CNG  
**B<sub>100</sub>** – 100% biodiesel  
**B<sub>20</sub>** – 20% biodiesel w/ petroleum diesel  
**CNG** – compressed natural gas (up to 3600psi and beyond)  
**CH<sub>4</sub>** - methane  
**LNG** – liquefied natural gas (cryogenic)  
**NGV** – natural gas vehicle  
**E<sub>85</sub>** – 85% ethanol w/ gasoline (E10, E30, E95, etc...)  
**LPG** – liquefied petroleum gas (propane)  
**FFV** – flex-fuel vehicle  
**FCV** – fuel cell vehicle  
**FCHV** – fuel cell hybrid vehicle  
**RVO** – recycled veggie oil  
**SVO** – straight veggie oil  
**WVO** – waste veggie oil  
**ICE** – internal combustion engine  
**H<sub>2</sub>ICE** – hydrogen internal combustion engine  
**EV** – electric vehicle  
**NEV** – neighborhood electric vehicle  
**HEV** – hybrid electric vehicle  
**PHEV** – plug in hybrid electric vehicle  
**AFV** – American fuel vehicle (a.k.a. alternative fuel vehicle)  
**CFV** – cleaner fuel vehicle  
**BTU** – British thermal unit  
**G.G.E.** – gasoline gallon equivalent  
**CRD** – common rail diesel  
**TDI** – turbo direct injection

## Fuel Hierarchy Pyramid

From existing infrastructure, most desirable to least desirable

Renewable Hydrogen  
Renewable Methane  
Ethanol  
Biodiesel  
Veggie Oil  
Finite Hydrogen  
Finite Methane  
Methanol  
Propane  
Gasoline  
Diesel

## Cleaner Fuel Vehicles - Saving You Money in America

### Glossary of Terms:

**Hydrogen** – that which creates water

**Finite Hydrogen** – sourced from non-renewable sources such as petroleum

**Solar Hydrogen** – infinite supply when renewable (wind, wave, PV, etc.) electricity is used to “mine” hydrogen from water

**Renewable Hydrogen** – any process that sustainably produces hydrogen

**Compressed Hydrogen Gas** – H<sub>2</sub> stored at high pressure up to 10,000psi today

**Producer Gas** – H<sub>2</sub> + CO derived from smoldering coal in an oxygen deprived state, (a.k.a. Towns Gas)

**Liquefied Hydrogen** – cryogenic, below -252.7 degrees Celsius

**Solid Hydrogen** – a heavy matrix commonly from powdered metals that act like a sponge to store H<sub>2</sub>

**Methane** – a molecule composed of one carbon and 4 hydrogen atoms, CH<sub>4</sub>, majority component of natural gas

**Fossil based CH<sub>4</sub>** – found in underground wells, such as from coal bed methane

**Renewable CH<sub>4</sub>** – collected farm waste, decomposing matter, bio-gas, sewage treatment plants, etc...

**Natural Gas Vehicle** – light and heavy-duty vehicles whose engines burn methane, NGV

**Compressed Natural Gas** – CNG stored up to 3,600psi and beyond..

**Liquefied Natural Gas** – LNG, cryogenic stored in vacuum container for heavy duty vehicle fuel

**Ethanol** – an alcohol derived from crops such as corn and switch grass that can be used as a motor fuel

**Biodiesel** – a processed fuel from fresh or recycled oils and greases for use in compression ignition engines

**Veggie Oil** – fuel derived from plants, either used straight with a heated tank, or processed into biodiesel

**Yellow Grease** – used restaurant fats and oils, a feedstock for biodiesel

**Propane** – a conglomeration of petroleum based fuels such as methane, butane, etc...

**Liquefied Petroleum Gas** – propane stored under pressure as a liquid, (a vapor at atmospheric pressure)

**Gasoline** – a toxic fuel refined from finite petroleum crude oil, (a.k.a. petrol the world over)

**Diesel** – a toxic fuel refined from finite petroleum crude oil

**Compression Ignition Engine** – combustion from heat and pressure, a diesel engine

**ICE** – internal combustion engine, burns fuel to produce mechanical movement and waste heat

**Electric Drive** – motors that silently propel a vehicle with electric current either from batteries, capacitors or a fuel cell

**Hybrid Vehicle** – combining two or more forms of propulsion to the drive wheels, (i.e. ICE + electric motors)

**Fuel Cell** – a machine that chemically combines hydrogen with oxygen, thus producing water, heat and electric current

**Capacitor** – an electrical storage device used to deliver high voltage to an electric motor

**Flex-Fuel Vehicle** – capable of operating on varying blends of different fuels that are stored in the same or separate fuel tanks

**Bi-Fuel Vehicle** – capable of utilizing two different fuels with separate fuel storage systems, (a.k.a. bivalent)

**Dual-Fuel Vehicle** – an engine capable of operating on two separate fuels from separate tanks at the same time

**Tri-Fuel Vehicle** – capable of operating on three separate fuels, though only one at a time

**Multi-Fuel Vehicle** – capable of operating on 4 or more fuels with multiple, separate fuel storage systems

**Hydrogen Boosting** – fumigating H<sub>2</sub> on top of any baseline fuel to increase combustion and obtain better performance

**Pilot Point Ignition** – using the compression ignition of a baseline fuel to ignite H<sub>2</sub>, CH<sub>4</sub> or LPG

**Electrolysis** – process by which hydrogen and oxygen are released from water with an electric current

**Up-Fit** – upgrading an existing vehicle to become more capable and operate on more fuels than originally designed for

**Extended Range Package** – adding compressed fuel storage vessels to a vehicle to increase driving range

**Fuel System Upgrade** – adding a new fuel storage and delivery system to a vehicle, (a.k.a. conversion)

# INTERGALACTIC HYDROGEN : American Fuel Vehicles

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### Fuel Compatibility Chart Listed by Engine Type

Vehicle Engine Type	Hydrogen	Methane	Ethanol	Biodiesel	Veggie Oil*	Propane	Gasoline	Diesel	Hybrid Electric
Multi-Fuel compression ignition engine	x	x	x	x	x	x		x	optional
Multi-Fuel 4-stroke engine	x	x	x			x	x		optional
Tri-Fuel 4-stroke engine	x	x	E30				x		optional
H2 up-fit of existing CNG vehicle	x	x							optional
H2 up-fit of existing CNG/gasoline vehicle	x	x	E30				x		optional
Any diesel engine vehicle:				x	heated tank			x	
Jeep Liberty CRD, Ford Powerstroke				x	heated tank			x	
Volkswagen Touareg TDI, CAT, etc....				x	heated tank			x	
Flex Fuel Vehicles (FFV's):			E85				x		
Nisan Titan, GM 5.2L V-8's, etc....			E85				x		
Factory bi-fuel CNG/gasoline vehicles	H20	x	E30				x		
Factory bi-fuel propane/gasoline vehicles			E30			x	x		
Factory CNG dedicated vehicles	H20	x							
Any Gasoline engine vehicle			E30				x		
Hybrid gas electric vehicles			E30				x		x
Hybrid diesel electric vehicles				x	heated tank			x	x
Fuel Cell Vehicle (FCV)	x								
Fuel Cell Hybrid Vehicle (FCHV)	x								x

\* Veggie Oil requires heated fuel tank upgrade.

Compression ignition engines can run any blend of petroleum diesel mixed with biodiesel up to B100 without modification.

Any gasoline engine can run up to E30 without modification. Only E10 is officially recommended.

Commercial Ethanol is always blended with at least 5% gasoline so you do not drink it!

Compressed Hydrogen, (H2) and methane, (CNG) are compatible and can be stored in the same fuel tanks or blended together.

Propane, (LPG) requires its own fuel tank.

The great thing about hybrid technology is that it is fuel neutral. Hybrid electric motors can be coupled to any drive train and a plethora of fuel types.

*Intergalactic Hydrogen provides cleaner fuel options that work with today's infrastructure and beyond. We build multi-fuel, hydrogen, methane, propane, biodiesel and ethanol automobiles and appliances. We promote the clean fuel revolution through educational workshops and engineering consultation. Reduce your footprint on the planet with American Fuel Vehicles (AFV's) and declare your energy independence.*